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Abstract

OPTIMUM DIGITAL INFORMATION HANDLING AND NUCLEAR ENGINEERING INSTRUMENTATION

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The signals treated by nuclear physics and engineering instrumentation are subjected in many cases to statistical disturbances the presence of which is their characteristic property. These disturbances are due to the statistical nature of physical processes, information about which must be given by means of treatment of the input signals. The problem of the optimum treatment of information in the presence of statistical disturbations is solved theoretically by the theory of Wiener, which is directly applicable for the instrumentation having a continuous physical quantity at their inputs and outputs. At high requirements on accuracy, the applicability of this type of apparatus and filter is limited. In addition, it is not always simple to design the instrumentation which approximates the characteristics of an optimum mathematical model according to Wiener theory using the real details.

It is necessary, therefore, to pay attention to the use of digital computers. The following important problems arise, namely:

(1) What algorithm of the digital computer is to be used?
(2) How will the requirements on the accuracy of the results and on the speed of obtaining them affect the requirements on complexity and calculation speed of the computer?
(3) What is the theoretical limit of accuracy regarding the given problem and how do the results computed by the computer approximate to the theoretical limit at the selected algorithm and at selected computer parameters?

Interesting results, i.e. the relatively simple digital computer structure, the possibility to determine simply the theoretical accuracy limit and at the same time the possibility of a "nearly complete" exploitation of the input information, were obtained using following algorithm: the input signal is a

vector of a finite dimension. The components of this vector are given by the finite series of sums of non-random and random function values, the basic statistical parameters of the latter being given. The output signal is obtained as the scalar product of the input vector and the vector-operator. The components of the vector-operator are determined by the requirement of the given analytical accuracy, by the minimum result dispersion and by the type of the linear transformation applied to the input non-random function. Special cases of this problem are as follows: digital interpolation, extrapolation and filtration of the input values of the non-random function, its derivatives, integrals and/or its linear transformations.

These operations are carried out on the base of inaccurate values of the input function, which are given at different points of the finite observation interval. The digital computer has the same task as the optimum filters with a finite memory, which are fed with continuous signals.

The merit of the selected algorithm is the possibility to compute the vector-operator for the given task once and for all and to simplify the digital computer in this way. The passage to another problem is enabled by the digit (vector-operator components) intercharge without any structure and instrumentation component change.

Fundamental theoretical results necessary for practical computations are mentioned in the report. The examples of using this approximation to some nuclear physics and engineering problems are given. Accurate reactor power and period measurements, reactor prompt reactivity measurement using reactor kinetics equations etc. are given as possible utilization regions. The necessity of a passage to digital computers increases with increasing the accuracy requirements and with increasing the transformation complexity which is to be performed by the computer being especially affected by the statistical components of the input signal.